TECHNICAL REPORT 3085

SHOCK INITIATION THROUGH A BARRIER

ROBERT L. WAGNER

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PICATINNY ARSENAL
DOVER, NEW JERSEY

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BY

ROBERT L. WAGNER

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SUBMITTED BY: D. E. Seeger
D. E. SEEGER
Chief, Explosives
Initiator Section

APPROVED BY: E. H. Buchanan
E. H. BUCHANAN
Chief, Artillery
Ammunition Laboratory

AMMUNITION ENGINEERING DIRECTORATE
PICATINNY ARSENAL
DOVER, NEW JERSEY

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SECTION I

INTRODUCTION

Barriers in explosive trains are common. They usually exist because the construction of the fuze or device requires it, rather than out of consideration for the explosive train. However, in some cases, such as in the "burning to detonation" type detonator, barriers are introduced to aid in propagation of the explosive train. Another exception is where barriers are introduced for the purpose of shaping the detonation wave. The barriers which exist in normal explosive trains -- regardless of why they are there -- are usually disrupted, fragmented, broken or severly damaged when the train is exploded. The reason is that the transfer of detonation from one component to another is usually easier if the barriers can be destroyed. Consequently, there is seldom any need to keep barriers intact except to interrupt propagation.

However, it is foreseen that transfer of detonation or propagation through a barrier without disrupting or perforating the barrier is reasonable enough. Such a design suggested itself recently as a solution to an initiation problem with a proposed rocket motor.

This report summarizes feasibility study results of the practicality of initiating a rocket motor through a barrier using the shock of a high explosive charge but without perforating the barrier.

SECTION II

SUMMARY

The results of a feasibility study of the practicality of initiating a rocket motor through a barrier using high explosives without perforating the barrier are summarized. Results indicated that a variety of explosives and barriers could be made to work in such a system. For certain reasons (detailed in Section V), a system was designed in which the design parameters consisted of PETN which is initiated by shock through a 0.1-inch steel barrier. This was applied to initiation of a rocket motor with success.

SECTION III

CONCLUSION

It is concluded that using high explosives to initiate a propellant train through a barrier without perforating the barrier is practical.

SECTION IV

RECOMMENDATION

A failure mode analysis of the subject system should be conducted.

SECTION V

STUDY

A series of experiments were conducted in which the M55 Stab Detonator was confined in an aluminum sleeve and functioned over various thicknesses and type materials (Figure 3). The test set-up is shown in Figure 1. The damage to the metal plate caused by the detonator was observed.

The M55 stab detonator contains a base charge of 19 mg of RDX. Pinhole perforations were made in 0.063" thick brass while only dents were observed in 0.115-inch thick stainless steel. Table 1 outlines the materials used and the test results.

Actually, there is little which can be concluded from these initial tests. From the results, however, it seemed likely that the study had at least been launched in the proper direction.

Another series of tests were conducted in which either the M55 Stab Detonator (Figure 3) or the M47 Stab Detonator (Figure 7), confined in an aluminum sleeve, was functioned over various thicknesses and type materials. Different explosive components were placed on the other side of the metal plates. Observed was damage to the metal plate barrier and whether the acceptor component was initiated when the donor component functioned.

The test set-up is shown in Figure 4. Test results are in Table 2.

The next test series was very similar to those just described except that some of the donor components were electric initiators and the confinements varied.

The test results are in Table 3.

Table 2 and 3 show results of the first tests conducted using explosives on both sides of the barrier. Some interesting observations can be made from the results. One is the fact that when explosives are used on both sides of the barrier, the barrier will be more resistant to being perforated. Undoubtedly this effect is a result of the pressure and shock from the detonation of the acceptor component giving support to the barrier. This effect should permit use of larger donor and acceptor charges with thinner barriers.

Another observation is that the functioning time of the initiation system must be very short. This is inferred from the previous discussion. If there were an appreciable delay in initiating the acceptor explosive there would be severe denting, if not penetration, of the barrier. There was a requirement that the initiation of the rocket motor not take more than one millisecond. Although no time measurements were made, it was judged that the initiation would be accomplished in less than the one millisecond.

Hardware which would facilitate further testing was designed as a result of the success obtained in the experiments in Table 2 and 3. This is shown in Figure 8. Five cylinders (Figure 8) were loaded as shown in Table 4. The loaded cylinders were tested in a manner similar to tests previously described. The test set-up is shown in Figure 9. Test results are in Table 5.

At this point, it was felt that the feasibility of the proposed system was adequately demonstrated, and consideration was given to the development of specific components for use in an actual rocket motor. It was decided that an electric detonator .147" - .006" diameter would be the test vehicle used for the donor component to cause initiation of the rocket motor. This judgment was based on availability of parts in a size compatible with charge requirements indicated in the tests. A number of these electric detonators were loaded and tested, using different amounts of various explosives to establish a final donor charge design and indicate an appropriate acceptor charge design.

The first experiments with the new electric detonators were made using detonators loaded as shown in Figure 10. Results of tests to determine ability of these detonators to initiate another explosive through a barrier are in Table 6. The test set-up is shown in Figure 11.

At the conclusion of these tests, a decision was made to eliminate lead azide and other primary explosives from the initiation system. This is desirable since primary explosives are regarded as being more sensitive than secondary explosives. This worked no particular hardship since the testing to date indicated that the desired end result could be accomplished using only secondary explosives.

Experiments were conducted to establish suitable secondary explosive donor and acceptor charges for initiation of PETN through a .100 inch steel barrier. These tests are in Table 7. The set-up used in most tests is shown in Figure 11. Exceptions to this test set-up are shown in the table. It should be noted that despite the decision not to use lead azide in the final system, a small charge of lead azide was loaded in the donor components used for test purposes. In the final system design this donor component would be replaced with a secondary explosive charge. This was done because it was considered expedient to continue t sting this way. However, the acceptor charge which is actually an integral part of the rocket motor, contained only PETN.

Based on the test results, a final design of acceptor and donor components for use in the proposed rocket motor was established. These are shown in Figure 12 and 13. These components were assembled to proposed rocket motor hardware (as shown in Figure 14) and tested. The initiation system functioned properly. The black powder was initiated and there was no perforation of the metal barrier. Damage to the parts did not appear to be severe, and it seemed likely that the seal provided by the O-ring was not broken.

After this study, a number of successful firings of complete rocket motors were made -- using the initiation system developed.

APPENDICES

APPENDIX A

TABLES

TABLE 1

DAMAGE TO VARIOUS METAL PLATES FROM AN M55 STAB DETONATOR

Type Material	Thickness, inch	Damage
Aluminum	.125	Spalled with pinhole perforation
Stainless Steel	.115	Dent but no perforation
Stainless Steel	.062	Spalled but no perforation
Brass	.063	Spalled with pinhole perforation

* M55 Stab Detonator contains a base charge of 19 mg RDX.

TABLE 2

INITIATION OF EXPLOSIVE COMPONENTS THROUGH A METAL BARRIER

Donor Component (1) (5)	Barrier		Acceptor Component (2) (3) (4) (6) (7)	Result		
	Material	Thickness		Acceptor Initiated	Component Not Initiated	Damage to Barrier
M55 Stab Detonator	Stainless Steel	.062	RDX Lead		X	No Perforation
M55 Stab Detonator	Aluminum	.125	RDX Lead		X	No Perforation
M55 Stab Detonator	Aluminum	.063	RDX Lead		X	Perforated
M55 Stab Detonator	Stainless Steel	.062	M55 Stab Detonator	X		No Perforation
M55 Stab Detonator	Mild Steel	.115	M55 Stab Detonator	X		No Perforation
M55 Stab Detonator	Mild Steel	.115	Flash Detonator	X		No Perforation
M47 Stab Detonator	Mild Steel	.115	RDX Lead		X	No Perforation
M47 Stab Detonator	Stainless Steel	.062	RDX Lead		X	No Perforation
M55 Stab Detonator	1020 Steel	.100	Flash Detonator	X		No Perforation

TABLE 2 (Cont'd)

Donor Component (1) (5)	Barrier Material	Barrier Thickness in.	Acceptor Component (2) (3) (4) (6) (7)	Result: Acceptor Initiated	Result: Component Not Initiated	Result: Damage to Barrier
M55 Stab Detonator	1020 Steel	.150	Flash Detonator	X		No Perforation
M55 Stab Detonator	1020 Steel	.100	Loose Black Powder		X	Cracked but no perforation
M55 Stab Detonator	1020 Steel	.100	Loose M31 Mix		X	No Perforation
M55 Stab Detonator	1020 Steel	.150	Loose LMNR		X	No Perforation
M47 Stab Detonator	1020 Steel	.150	Loose LMNR		X	No Perforation

(1) M55 stab detonator contains 19 mg RDX Base Charge (Figure 3)

(2) RDX Lead Dwg XP 114234 containing 254 mg RDX (Figure 5)

(3) Sensitive End of M55 Detonator which contains 15 mg NOL 130 Primer Mix was next to the barrier

(4) Flash Detonator shown in Figure 6. Sensitive End containing 90 mg of Dextrinated Lead azide was next to the barrier

(5) M47 Detonator shown in Figure 7 containing a base charge of 34 mg RDX

(6) M31 mix-55/45 potassium chlorate/lead thiocyanate

(7) All Loose Charges were in an aluminum cup. The cup was loaded flush to the top with the open end placed next to the barrier

TABLE 3

INITIATION OF EXPLOSIVE COMPONENTS THROUGH A METAL BARRIER

Donor Component			Barrier		Acceptor Component [2][3][5]			Result		
Type [1]	Confined	Not Confined	Material	Thickness, in.	Type [1]	Confined	Not Confined	Acceptor Component Initiated	Acceptor Component Not Initiated	Damage to Barrier
M51 Elect Det	X		1020 Steel	0.100	M51 Elect Det	X		X		No perforation
M55 Stab Detonator		X	4340 Steel	0.100	M51 Elect Det	X			X	No perforation
M47 Stab Detonator	X (See Fig 4)		4340 Steel	0.100	M51 Elect Det		X		X	Spalled & almost penetrated
M51 Elect Det	X		4340 Steel	0.100	M51 Elect Det		X	X		No perforation
M55 Stab Detonator	X (See Fig 4)		4340 Steel	0.200	Flash Det		X		X	No perforation
M47 Stab Detonator	X (See Fig 4)		4340 Steel	0.200	Flash Det		X	X		No perforation
M51 Elect Det	X		4340 Steel	0.200	M51 Elect Det		X	X		No perforation
M51 Elect Det	X		4340 Steel	0.100	M55 Detonator		X	X		No perforation

(1) Confinement used was an aluminum disc approximately 1" diameter x 0.250" thick with hole in the middle to accommodate the test component.

(2) M51 Detonator contains a base charge of 90 mg PETN. This detonator always positioned with base charge next to barrier plate.

(3) Flash Detonator shown in Figure 6. Sensitive End containing 90 mg of dextrinated lead azide was next to barrier plate.

(4) M47 Detonator is shown in Figure 7. Base charge containing 34 mg of RDX.

(5) Sensitive end of M55 Detonator which contains 15 mg of NOL 130 Primer Mix was next to the barrier.

TABLE 4

(1) CYLINDERS CONTAINING EXPLOSIVES

Cylinder No.	Explosive 1st Charge (2) (4)		2nd Charge (3)
	Material	Weight, mg	
1	M31 Mix	100	Black Powder
2	Black Powder	50	Black Powder
3	M31 Mix	50	Black Powder
4	M31 Mix	50	Black Powder
5	RD1333 Lead Azide	111	None

(1) Cylinders were 1" diameter x 1/2" high with a .131" + .001" hole through the center (See Figure 8).

(2) 1st charge loaded @ 10000 psi.

(3) 2nd charge loaded loose to fill cavity.

(4) M31 mix - 55/45 Potassium Chlorate/Lead Thiocyanate.

TABLE 5

INITIATION OF EXPLOSIVES THROUGH A BARRIER

Donor Component (2) (4) (5)	Barrier Material	Barrier Thickness, in.	Explosive (1) (3)	Cylinder No	Result
M47 Detonator	4340 Steel	.100	M31 Mix	1	Acceptor charge was initiated. Barrier was not perforated but was badly dented.
M47 Detonator	4340 Steel	.100	Black Powder	2	Acceptor charge was initiated. Barrier was spalled but not perforated.
M55 Detonator	4340 Steel	.100	M31 Mix	3	Acceptor charge was initiated. Barrier was not perforated but was badly dented.
Cylinder #5 (Table 4)	4340 Steel	.100	M31 Mix	4	Acceptor charge was initiated. Barrier was not perforated and not badly damaged.

(1) Loading details of cylinders shown in Table 4.

(2) M47 Detonator contains a base charge of 34 mg of RDX (Figure 7).

(3) M31 mix - 55/45 potassium chlorate/lead thiocyanate.

(4) Cylinder #5 was initiated using an electric primer XM89 which contains 25 mg dextrinated lead azide.

(5) M55 Detonator contains a base charge of 19 mg RDX (Figure 3).

TABLE 6

EVALUATION OF DONOR COMPONENTS

(1) Donor Component	Barrier		(2) Acceptor Comp	Result Acceptor Comp	
	Material	Thickness, in.		Initiated	Not Initiated
165 mg RD1333 Lead Azide	1020 Steel	.100	Flash Detonator	X	
100 mg RD1333 Lead Azide	1020 Steel	.100	Flash Detonator	X	
50 mg RD1333 Lead Azide	1020 Steel	.100	Flash Detonator		X
165 mg RD1333 Lead Azide	1020 Steel	.150	Flash Detonator	X	

(1) Detonators as shown in Fig 10.

(2) Flash Detonator shown in Figure 6. Sensitive End containing 90mg Dextrinated PbN_6 was next to barrier.

TABLE 7

EVALUATION OF DONOR COMPONENTS CONTAINING PETN

Donor Component		Barrier		Acceptor Component			Result
Component	Base Charge wt.	(2) Material	Thickness, in.	Explosive	Consolidation Pressure, psi	Metal Part	
Donor Component (Figure 10)	72 mg PETN	Steel	0.100	PETN, 53 mg	10,000	M55 Detonator cup	(1) Severe damage to barrier. Initiation of acceptor comp questionable.
M51 Elect Detonator	90 mg PETN	Steel	0.100	PETN, 53 mg	10,000	M55 Det. Cup	(1) Barrier penetrated. Initiation of acceptor charge questionable.
M51 Elect Detonator	90 mg PETN	Steel	0.100	PETN, 90 mg	15,000	M47 Det Cup, No discs.	Acceptor Comp was initiated. Barrier not penetrated.
M51 Elect Detonator	90 mg PETN	Steel	0.100	PETN, 90 mg	15,000	M47 with 0.002" thick disc	Acceptor Comp was initiated. Barrier not penetrated.
Donor Comp (Figure 10)	72 mg PETN	Steel	0.100	PETN, 90 mg	15,000	M47 with 0.002" thick disc	Acceptor Comp initiated. Barrier not penetrated.
Donor Comp (Figure 10)	72 mg PETN	Steel	0.100	PETN, 90 mg	15,000	M47 with 0.002" thick disc	(3) Same as above.
Donor Comp (Figure 10)	40 mg PETN	Steel	0.100	PETN, 50 mg	15,000	M55 Det Cup	(3) Acceptor was initiated. Barrier not penetrated.
Donor Comp (Figure 10)	50 mg PETN	Steel	0.100	PETN, 50 mg.	15,000	M55 Det Cup	Acceptor was initiated. Barrier not penetrated.
Donor Comp (Figure 10)	30 mg PETN	Steel	0.100	PETN, 50 mg	15,000	M55 Det Cup	Failed

(1) No confinement used for acceptor charge.

(2) A mild steel - Exact type not known.

(3) Loose black powder placed below acceptor component was ignited.

APPENDIX B

FIGURES

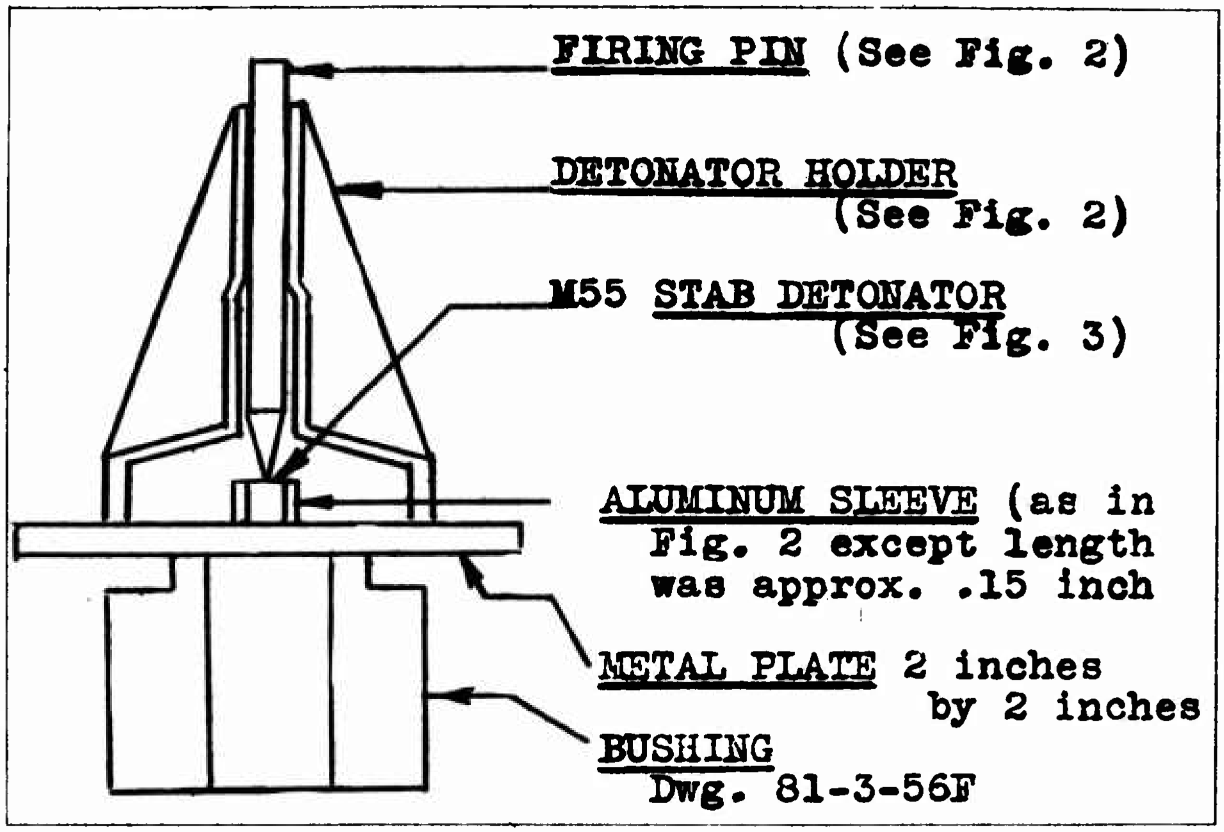

Figure 1. Test Set-Up For Plate Damage Tests

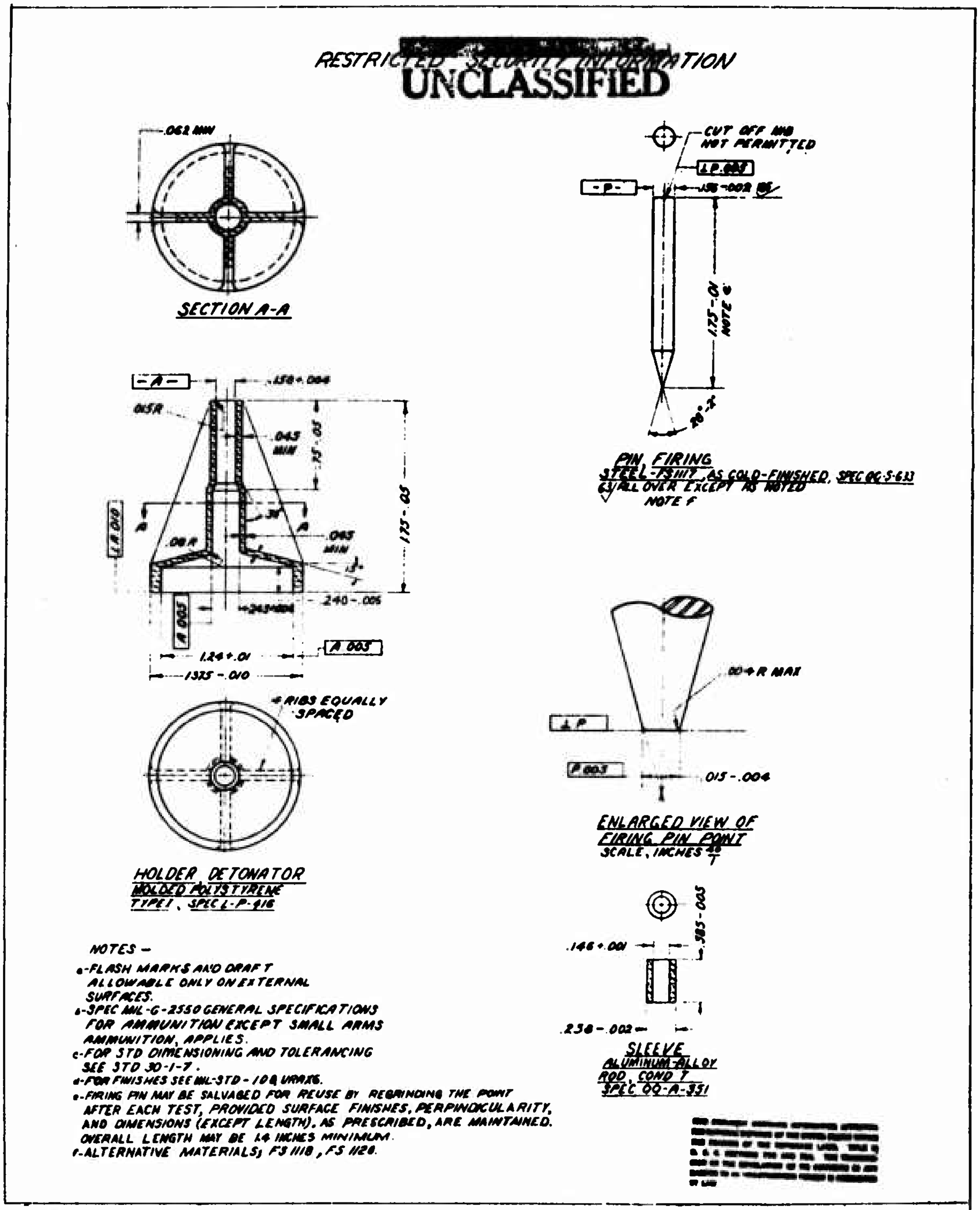

Figure 2. Detonator Holder and Firing Pin

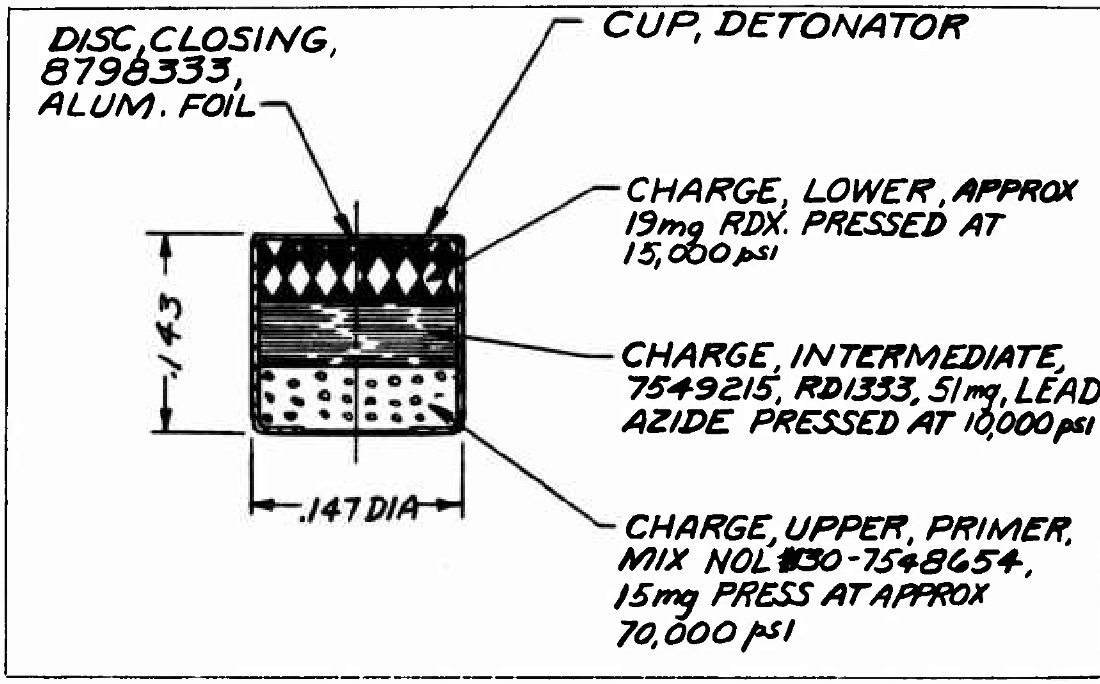

Figure 3. Detonator, Stab, M55

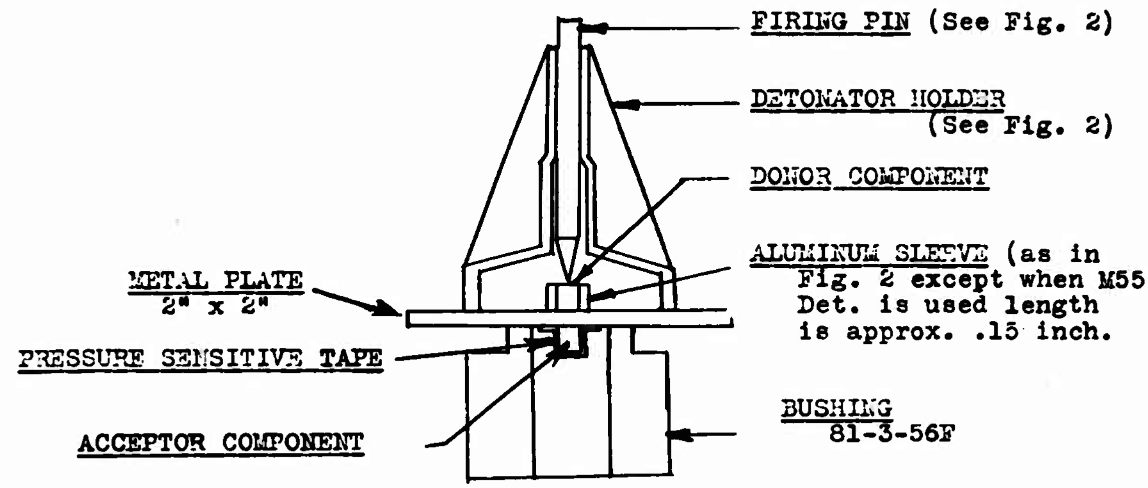

Figure 4. Set-Up For Testing Component Initiation Through A Barrier

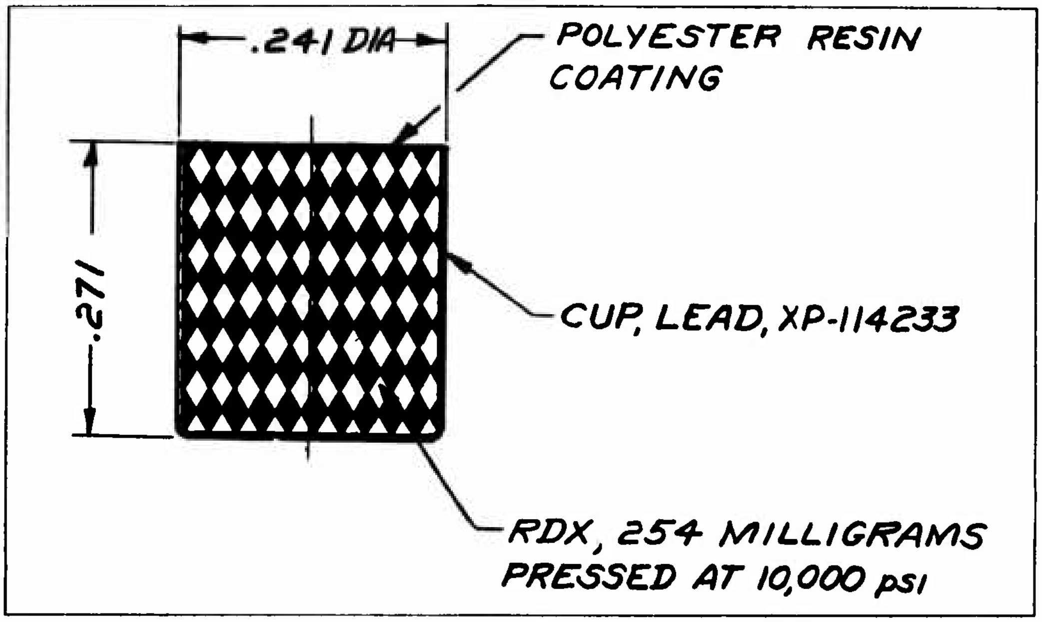

Figure 5. Loaded Lead Assembly

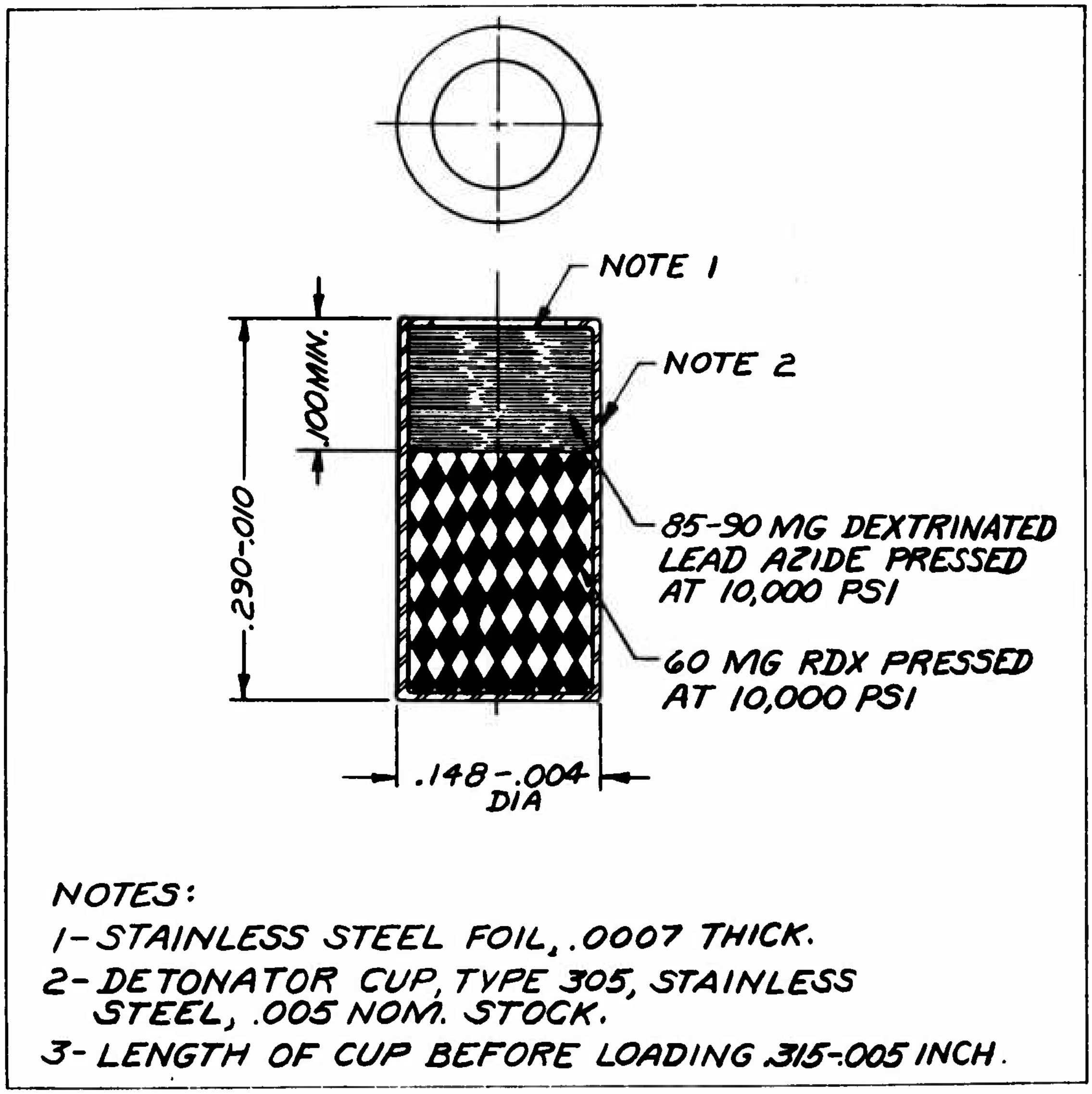

Figure 6. Flash Detonator

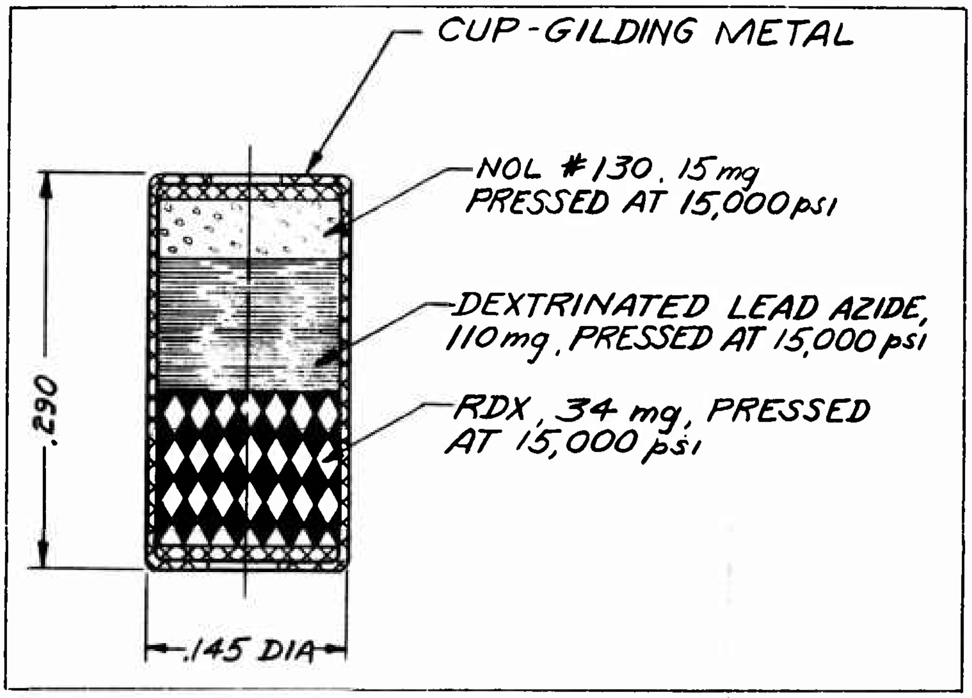

Figure 7. M47 Detonator

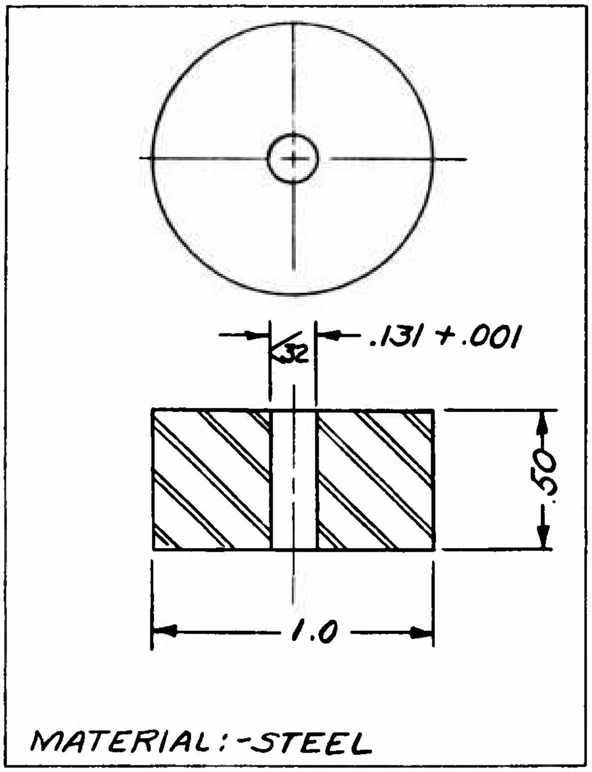

Figure 8. Cylinder

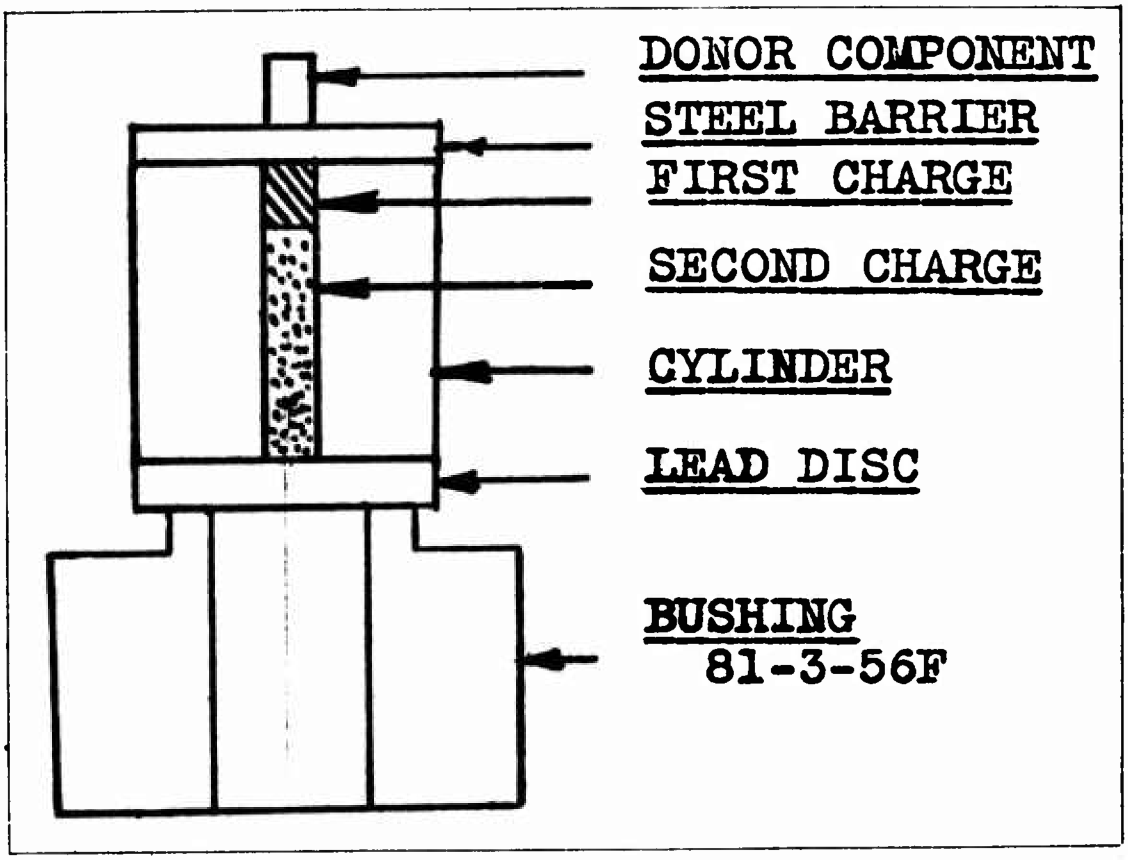

Figure 9. Set-Up For Testing Explosive Initiation Through A Barrier

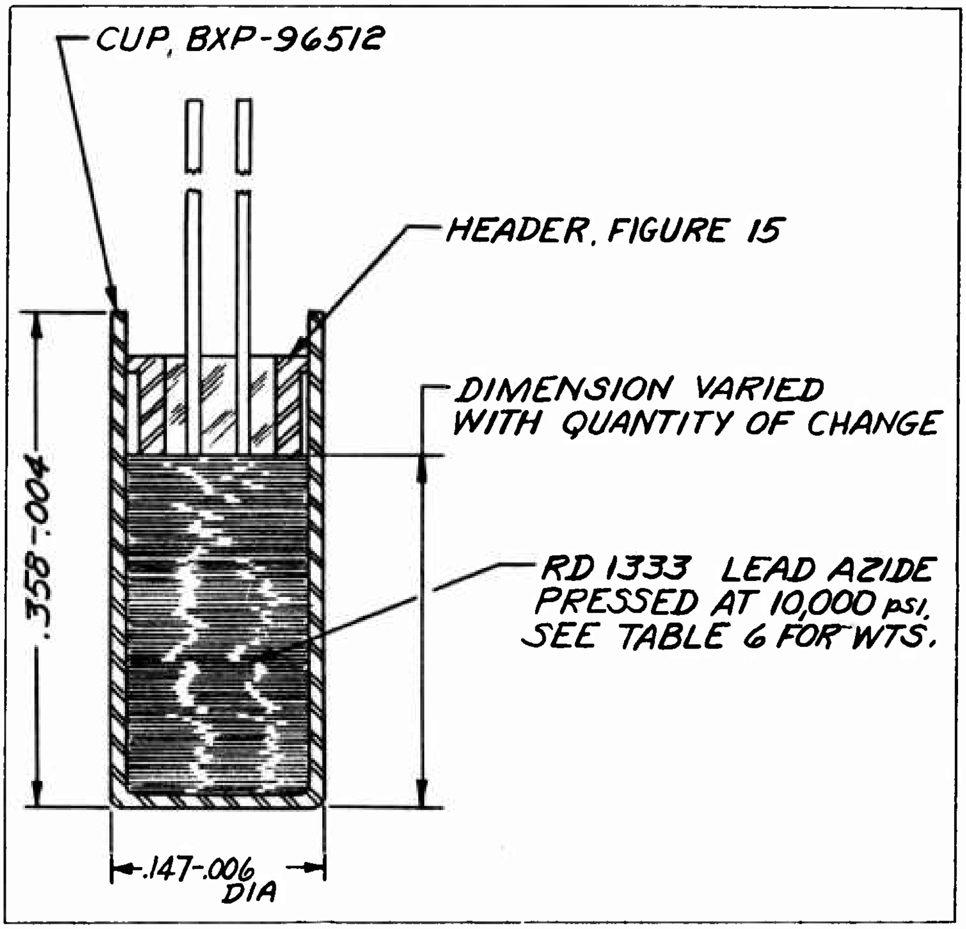

Figure 10. Donor Component

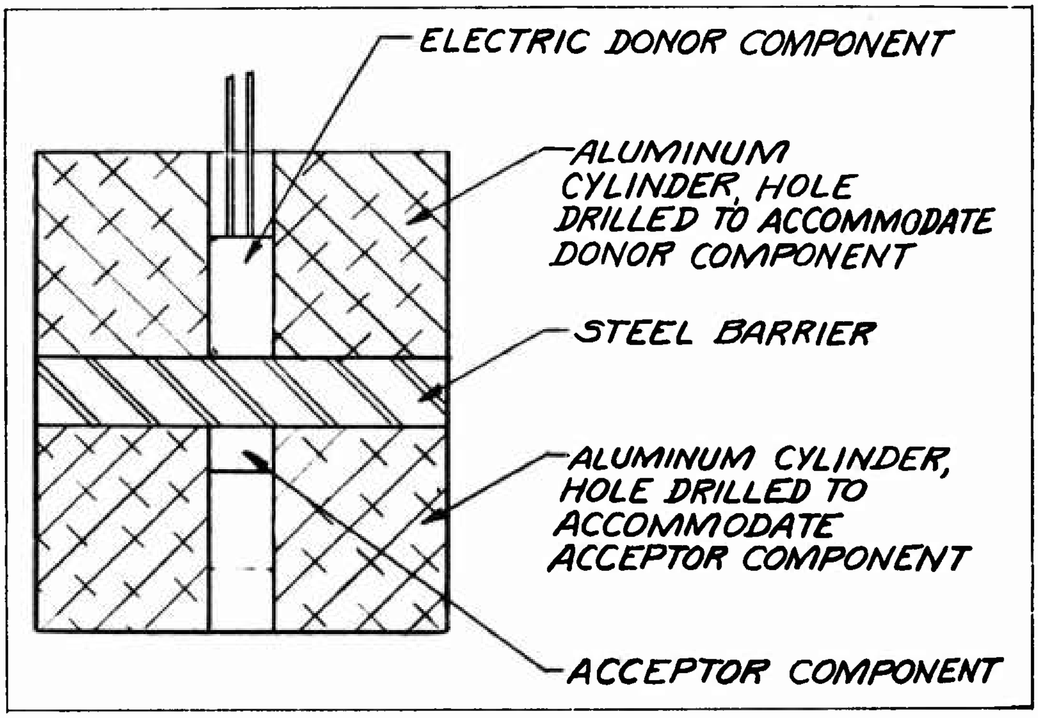

Figure 11. Test Set-Up For Evaluation Of Electric Donor Component

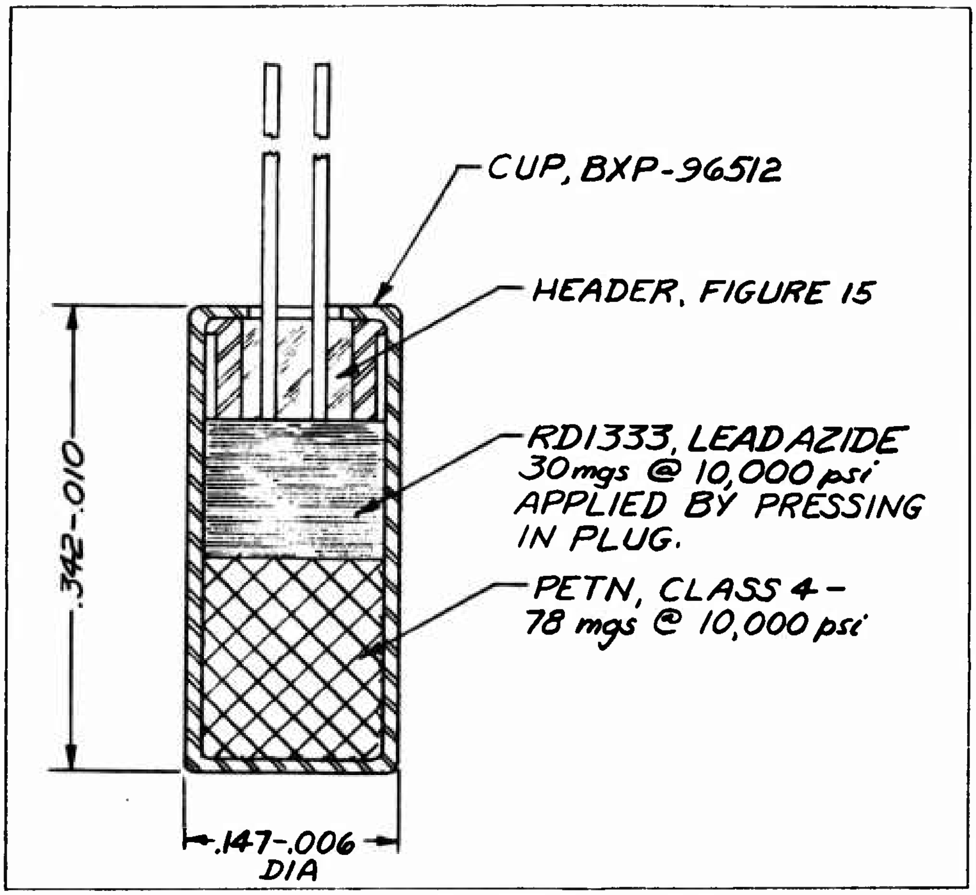

Figure 12. Donor Component

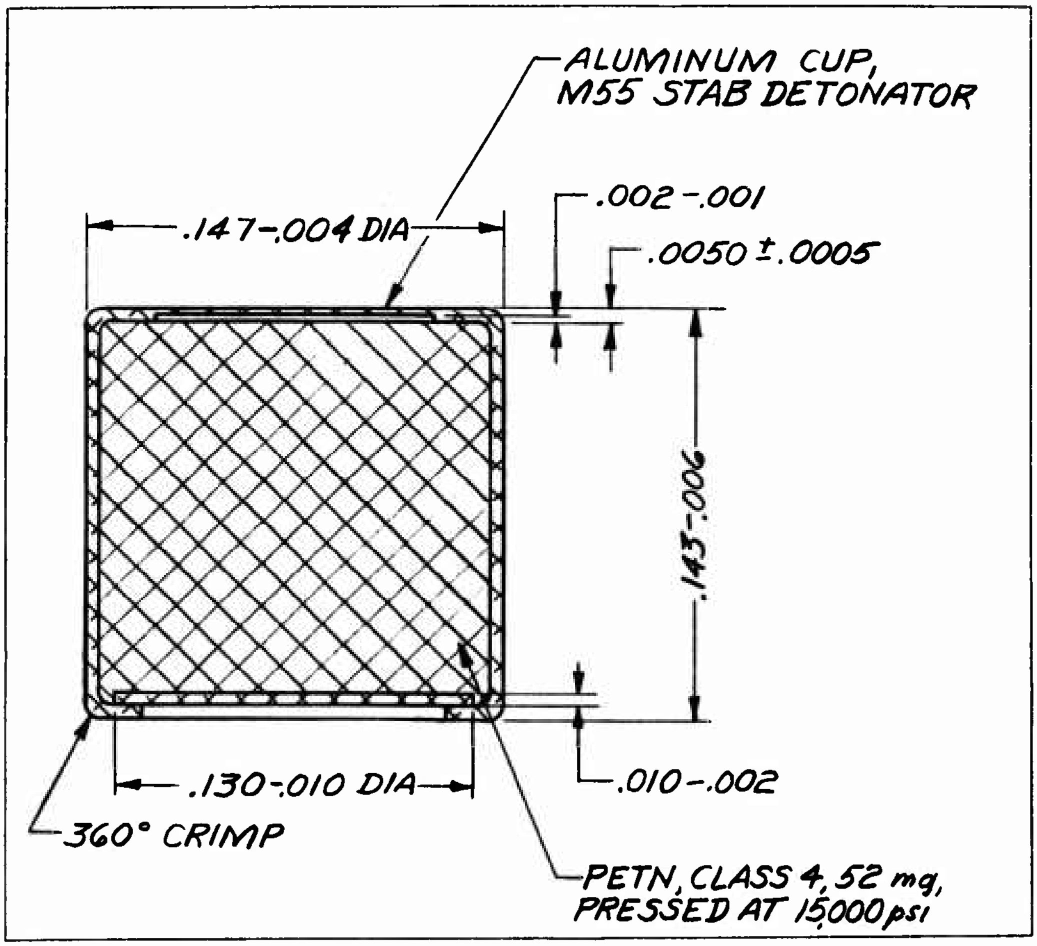

Figure 13. Acceptor Component

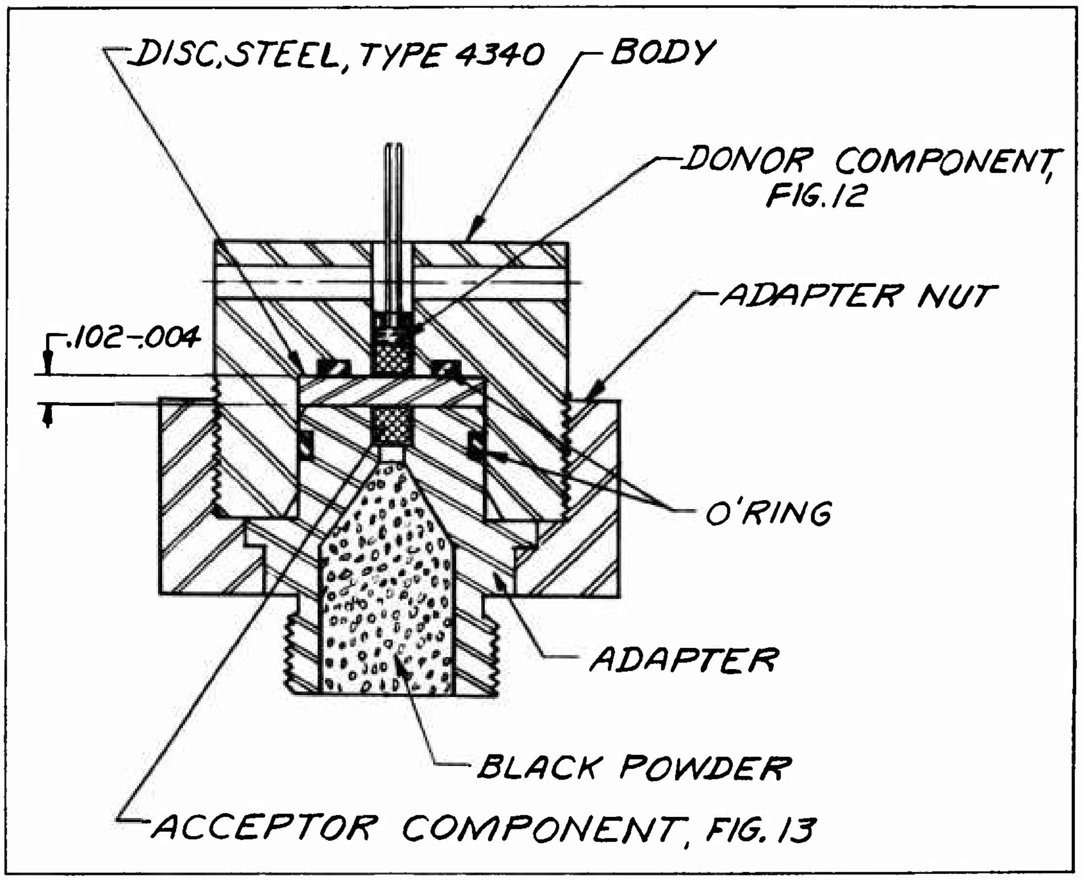

Figure 14. Rocket Motor Test Assembly

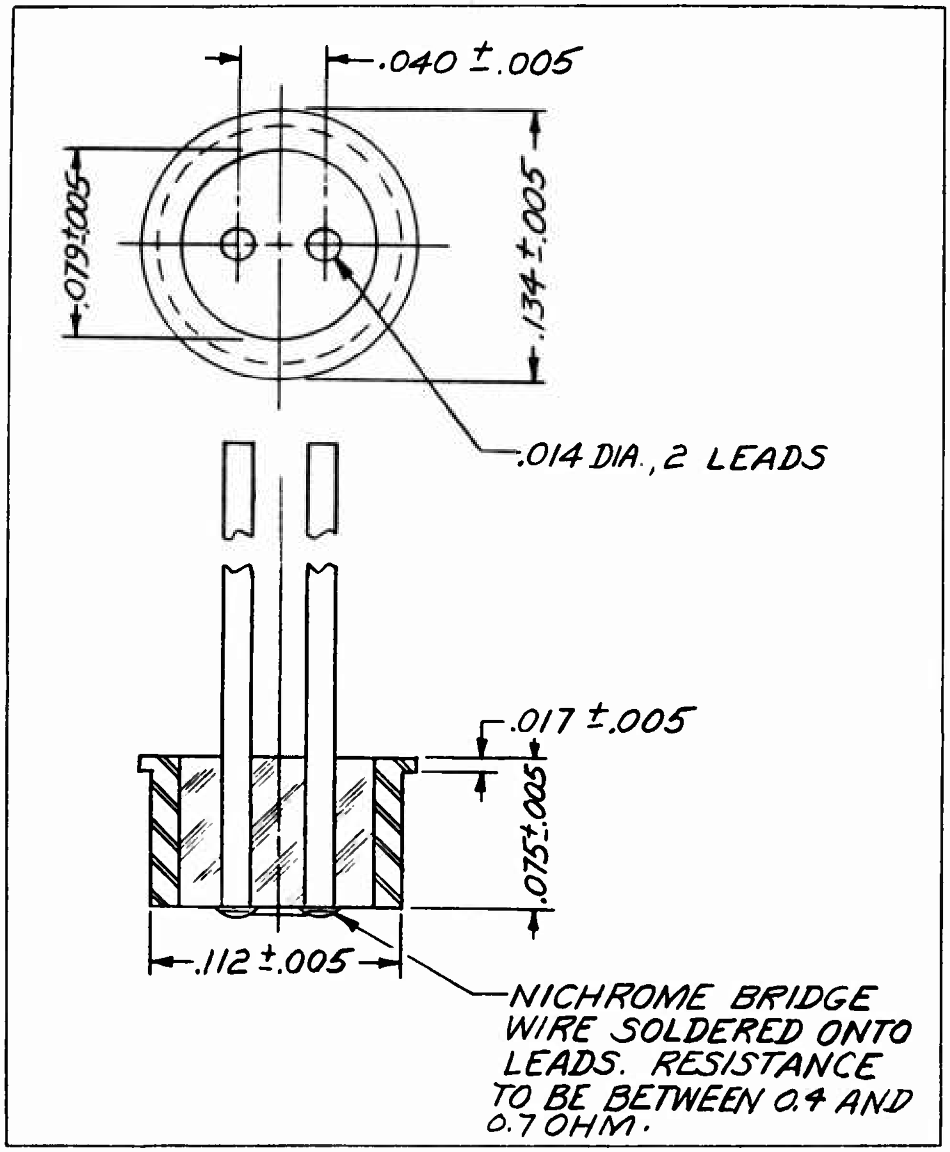

Figure 15. Header And Bridge Assembly

ABSTRACT DATA

ABSTRACT

Accession No.______________AD______________

Picatinny Arsenal, Dover New Jersey

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II. Shock initiation

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It was concluded that using high explosives to initiate a propellant train through a barrier without perforating the barrier is practical and a failure mode analysis of this system should be conducted.

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1. Explosive Initiators

I. Wagner, Robert L.
II. Shock Initiation

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